Clinical Interventions in Aging

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REVIEW

Digital Assistive Technology to Support Everyday Living in Community-Dwelling Older Adults with Mild Cognitive Impairment and Dementia

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Objective: The objective of this review was to explore whether knowledge about and practice of technology for older adults with mild cognitive impairment (MCI) and dementia (D) had developed since our 2017 review. Furthermore, we wanted to explore the usability and acceptability of technology in the newer trials, and how these may impact quality of life, occupational performance and human dignity.

Materials and Methods: We searched for primary studies published between 2017 and 2020 reusing medical subject heading (MeSH) terms in five databases – Medline, PsycINFO, Embase, Amed and Cinahl – and obtained 1452 titles. The titles were divided in six piles, two for each of the three authors. The titles were sorted utilizing the Rayyan web tool. Fourteen studies were included in this review. The Mixed Method Appraisal Tool (MMAT) was used to assess the quality of the studies examined.

Results: This review included almost twice as many participants as in the 2007–2017 review. Since 2017, a shift seems to have occurred toward technologies that can be worn on the body to monitor body functions and report states, or imbalances. Moreover, research interest is now focused on mobile phone apps and wearables providing reminders and timely support, rather than on separate devices at home.

Conclusion: The studies conducted since 2017 report on wearable and environmental digital assistive technologies and often with multiple purposes. Three strategies for support seem evident: prompting and reminding people with dementia, monitoring people with dementia at home using environmental sensors and biosensors and providing safety outdoors. Thus, there is still a need for further research on the impact of technologies promoting occupational performance, quality of life, and human dignity for independent living.

Keywords: technology, Alzheimer's disease, coping, ageing in place, quality of life, human dignity

Introduction

Norwegian health policy encourages older citizens to remain at home for as long as possible and to stay active and fit.[1–4] Government strategies recommend participation in activities and socialization to preserve health and well-being. Older citizens should be enabled to master independent living at home during their lifetime.[2] Due to expected demographic changes, the numbers of older adults with mild cognitive impairment (MCI) and dementia (D) are expected to grow, both in Norway (demenskartet.no) and worldwide.[5,6] The prevalence of dementia in Norway in 2020 was 101,800 and is expected to more than double to 238,499 by 2050.[7] Dementia is a general term for chronic or progressive neurodegenerative diseases that affect the brain and influence cognitive function, psychological health, behavior, motor skills, and the ability to cope with everyday life.[8]

Dementia increases with age, and the most frequent type is Alzheimer's disease (60–70%). Vascular dementia, Lewy body dementia and frontotemporal dementia are other major types. MCI is a neurocognitive disorder, often attributable to an underlying disease of the nervous system, an infection, or to trauma to the brain.[9] MCI may progress to dementia, remain stable or gradually recover/disappear. However, mortality rate is high.[10] Frequently reported problems for people with MCI/D

Received: 11 January 2022
Accepted: 30 March 2022
Published: 18 April 2022

include remembering appointments, planning and doing shopping, preparing food, paying bills, doing the laundry, and keeping track of day and night.[8] In the early phases of dementia, digital assistive technology is expected to support both the person with MCI/D and their family carer.

Digital assistive technology is expected not only to improve coping and safety for the person with MCI/D but also to alleviate the carer burden. Prior research has found that family carers of relatives with dementia are more often at risk of ill health and depression than family carers of relatives with other diseases.[11–13] However, the carer burden can be experienced differently. Family caregivers who considered themselves to have control of the situation were more likely to cope with their caring obligations.[11] A more recent study found that adult children carers considered themselves to play an important role supporting elderly parents in need of care.[14] Since 2011, community health care services have been encouraged to integrate digital assistive technology in the home care services to increase quality and efficiency in the health services and to reduce costs.[15] This is in line with international policy and research.[16–18]

More than 300 municipalities have joined the Norwegian national project to implement digital assistive technologies such as global positioning system (GPS), electronic medicine dispensers, and electronic door locks (to secure access for health care workers). Results from these trials demonstrate the potential economic benefits that can be realized within the home care services.[19] Expectations of the potential of technology to support older adults at home and the home care services are therefore high, however, it though contingent on usability and acceptability.

Usability is defined by International Organization for Standardization as

> the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.[20]

Weichbrot (2020) conducted a systematic literature review and identified many criteria for usability, among which learnability (easy to use), memorability (easy to remember how to use), cognitive load and errors were in the top seven, along with effectiveness, efficiency, and satisfaction.[21] Acceptability is defined as "the degree of primary users' predisposition to carry out daily activities using the intended device".[22–24]

In 2020 we reproduced the literature search to explore whether there had been any developments regarding trials of new digital assistive technologies to assist older adults with MCI/D at home. The research questions for the current literature review are:

- What types of technologies were explored in trials with home-dwelling older adults with MCI/D during 2017–2020?
- What were the main outcomes regarding usability and acceptability of the technology interventions?
- What was the impact on occupational performance, quality of life (QoL), and human dignity for independent living?

Materials and Methods

This systematic literature search identified literature published between January 2017 and September 2020.

Information Sources

We reused the same inclusion and exclusion criteria and the same search strategy as in the 2017 review. We searched in the five databases MEDLINE, PsycINFO, Embase, Amed and Cinahl using each base's medical subject heading terms (MeSH) to ensure validity in the respective thesauri (Table 1). Three specialist librarians at Oslo Metropolitan University assisted with the search in September 2020.

Inclusion Criteria

- Primary studies on technology trials with older people with mild cognitive impairment and dementia (MCI/D)
- Titles or keywords including technology or type of technology
- Titles or keywords including a population with mild cognitive impairment, dementia, early-stage dementia or Alzheimer's disease
- Home-dwelling older adults

Table 1 Search Strategy PsycINFO With Mesh Terms

1. dementia/ or dementia with lewy bodies/ or vascular dementia/ or alzheimer's disease/ or cognitive impairment/
2. memory disorders/
3. (mild cognitive impair* or dement* or alzheimer* or lewy body diseas* or memory disorder* or memory impair* or MCI).mp.
4. 1 or 2 or 3
5. assistive technology/
6. automation/ or artificial intelligence/
7. human machine systems/ or exp human computer interaction/
8. (assistive or self-help or everyday or daily living or dementia friendly or welfare) adj1 (technology or device* or aid*).mp.
9. (smart-home or AAL or ambient assisted living or home automation or sensor-based technology or sensor technology).mp.
10. (artificial intelligence or AI).mp.
11. 5 or 6 or 7 or 8 or 9 or 10
12. life satisfaction/ or satisfaction/ or "quality of life"/ or well being/
13. autonomy/ or "independence (personality)"/
14. well being/
15. client participation/
16. social behavior/ or involvement/ or respect/
17. dignity/
18. ("health related quality of life" or hrqol or "quality of life" or qol or well-being or wellbeing or satisf* or digni* or autonom* or participat*).mp.
19. 12 or 13 or 14 or 15 or 16 or 17 or 18
20. 4 and 11 and 19
21. limit 20 to yr="2017–2021"

Exclusion Criteria

- Not target population (MCI/D)
- Not primary study/technology trial
- Laboratory studies (including smart labs)
- Not technology for supporting everyday living eg wheel chairs, shower rails and seats, mobility aids, etc.
- Long-term care/nursing home/assisted living
- Conference papers, editorials, research protocols
- Review articles or meta-analyses
- Books, book chapters

The Study Selection

A total of 1452 references from the period 2017–2020 was identified. We used an adapted version of the Prisma statement for selecting papers.[25] After removing duplicates (47), 1405 references remained for screening to identify primary studies with the following selection criteria: MCI/D, technology, and home-dwelling. All titles were screened for relevance by all three authors using the Rayyan web-based tool, and those meeting the inclusion criteria were selected.[26] This resulted in 1365 papers being declined and 40 papers being deemed eligible for full-text reading. Twenty-six references were excluded after reading the full-text versions, due to wrong context (nursing home, assistive living or lab studies) (12), wrong population (not MCI/D) (3), wrong design (not primary study/trial) (10), or to being a conference paper (1). The number of remaining papers eligible for review was 14 (Figure 1).

The Review Processes

The three authors read all the 14 papers eligible for review. The quality of the papers was appraised according to the Mixed Method Appraisal Tool (MMAT), version 2018.[27] MMAT allows empirical studies, ie experimental, simulation or observational studies, and different research designs (qualitative, quantitative, and mixed method). Each author reviewed two-thirds of the papers, to meet the criteria of two authors being involved in the appraisal process and reaching agreement on each criterion.[27]

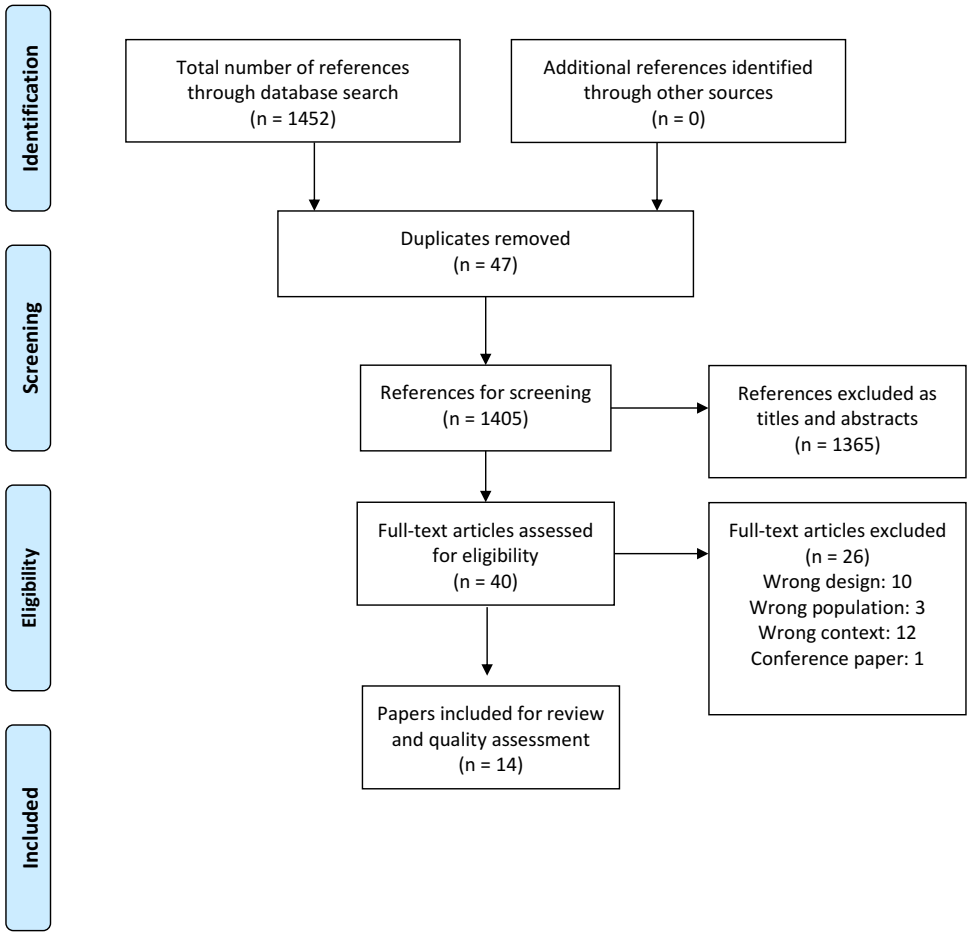

Figure 1 PRISMA flowchart for selection of papers. Adapted from Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009) Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med*. 2009;6(7): e1000097.[25]

Results

The 14 studies included in this review took place in UK (7), France (1), Germany (2), Finland (1), Greece (1), Denmark (1), and USA (1). By comparison, the top three countries conducting trials on technology with older adults with MCI/D in the 2017 review were: UK (five studies), the Netherlands (five studies) and Sweden (four studies). Moreover, the research design had changed; while the 2017 review largely consisted of research papers with a qualitative design and few participants, the 2020 review consisted of more research papers with quantitative design and more participants. The study design of the reviewed papers was distributed as follows:[27]

Design 1.Qualitative: 1 study

Design 2.Quantitative randomized controlled trials: 2 studies

Design 3.Quantitative non-randomized: 6 studies

Design 4.Quantitative descriptive: 2 studies

Design 5.Mixed method: 3 studies

Table 2 shows an overview of the quality of the papers included, according to MMAT. Numbers of Y (yes) indicate higher quality, ie seven Ys indicate the highest quality. Numbers of N (no) or CT (cannot tell) indicate lower methodological quality.

Table 3 provides an overview of abstracted data structured in the following categories: name of author, title of paper, year of publishment, doi, and country; type of technology used in the trial; aim and purpose of the study; design according to MMAT and quality assessment; number of participants with MCI/D, family carers/staff and age; method;

Table 2 Quality Assessment According To MMAT[20]

Citation	S1	S2	Study Design	Q1	Q2	Q3	Q4	Q5	Comments
Adrait 2017[28]	Y	Y	2	Y	Y	Y	Y	Y	High methodological quality
Boyd 2017[29]	Y	Y	3	Y	Y	Y	Y	Y	High methodological quality
Enshaeifar 2018[30]	Y	Y	4	Y	Y	Y	Y	Y	High methodological quality
Farina 2019[31]	Y	Y	1	Y	Y	Y	Y	Y	High methodological quality
Fowler-Davis 2019[32]	Y	Y	4	Y	N	Y	Y	Y	Reported negative on one quality measure
Harris 2021[33]	Y	Y	3	Y	Y	Y	N	Y	Reported negative on one quality measure
Kaimakamis 2017[34]	N	N	3	Y	Y	N	N	Y	Reported negative on four quality measures
McCarron 2019[35]	Y	Y	2	Y	Y	Y	N	N	Reported negative on two quality measures
McCauley 2019[36]	N	CT	5	Y	CT	Y	Y	Y	Reported negative on one quality measure, and failed to report on two quality measures
Megges 2018[37]	N	CT	3	Y	Y	Y	CT	Y	Reported negative on one, and failed to report on two quality measures
Nauha 2018[38]	Y	Y	3	Y	Y	Y	Y	Y	High methodological quality
Øksnebjerg 2020[39]	Y	Y	5	Y	Y	Y	Y	Y	High methodological quality
Schmidt & Wahl 2019[40]	Y	Y	3	Y	Y	Y	CT	Y	Failed to report on one quality measure
Tyack 2017[41]	Y	Y	5	Y	Y	Y	Y	Y	High methodological quality

Note: Numbers of Y indicate a high methodological quality.
Abbreviations: S, screening; Q, question; Y, yes; N, no; CT, cannot tell.

duration of intervention; reports on usability and acceptability; Reports on impact on QoL, occupational performance, human dignity; and results/conclusion.

Types of Technologies Identified and Categorized

To answer the first research question, the types of assistive technologies explored in trials with home-dwelling older adults with MCI/D during 2017–2020 can be categorized into five groups:

1.Wearables. Five papers on wearable technologies; wristband biosensors, smartwatches with GPS, wrist-worn activity monitors, and binaural hearing aids.[28,31,34,37] The purpose of these devices is to support safe and healthy living.

2.Environmental sensors and Internet-of-Things (IoT). Two papers on sensors communicating to promote reminders and safety at home and monitoring the home environment.[30,32]

3.Apps. Three papers exploring mobile phone apps to support activities of daily living (ADL), reminiscence, and a web-based mobile app and smartwatch.[35,36,42]

4.Tablet computers with touchscreen. Three papers on screens for prompting multi-step ADL tasks for viewing art.[29,33,41]

5.Various other supportive devices. Two papers. One on comparing the performance of using a blood pressure monitor, mobile phone and e-book reader in people with MCI/D and cognitively healthy, and one on four different

Table 3 Data Abstraction Sheet

Author, Year, Title, Journal, DOI and Country	Type of Technology	Aims and Purposes of the Study	Design According to MMAT	Number of Participants with MCI/D, Family Carers and Staff + Age	Method	Duration of Intervention	Report on Usability and Acceptability	Impact on QoL, Occupational Performance and Human Dignity	Results
Adrait et al. (2017)[28] Do Hearing Aids Influence Behavioral and Psychological Symptoms of Dementia and Quality of Life in Hearing Impaired Alzheimer's Disease Patients and Their Caregivers? J of Alzheimer Diseases, vol 58(1) 109–121 DOI: 10.3233/JAD-160792, France	Binaural hearing aids (HA)	To assess the efficacy of fitting binaural hearing aids to patients with age-related hearing loss (ARHL) and Alzheimer's disease (AD), as judged by neuropsychiatric symptoms, abilities for Instrumental Activities of Daily Living (IADL), and QoL of participants and their caregivers. Compliance and adverse effects with HAs were also investigated	MMAT design: 2 Quantitative RCT study: trial versus placebo multicenter randomized, double blind, controlled.	51 community-dwelling patients with ARHL and AD. Intervention group age: 83±6.2. Control group aged 82.3±7.3. All were living with an informal motivated caregiver (partner, child, friend, paramedical staff). FC collected data and reported on burden of care	Semi-crossover procedure over 12 months was conducted from 2006 to 2012. For the first 6 months, the active group was treated with active HAs and the placebo group with inactive HAs. For the last 6 months, HAs in the placebo group were activated. Assessment was conducted at baseline, 6 months, and 12 months. We performed intergroup and intragroup comparisons	12 months	n/a	No benefits regarding QoL for users and carers	Older people with hearing impairment and AD did not provide any benefit in terms of neuropsychiatric symptoms or activities of daily living, nor in the QoL of patients or caregivers, or provide evidence of improvement in behavioral symptoms, functional status, or QoL of hearing-impaired AD patients and their caregivers after 6 months of HA use. However, we cannot exclude that HAs may have a positive effect in patients aged below 75 years

Boyd et al. (2017)[29] Using simple technology to prompt multistep tasks in the home for people with dementia: An exploratory study comparing prompting formats. Dementia, vol 16(4) 424–442 DOI: 10.1177/1,471,301,215,602,417, UK	A touchscreen computer with prompts during two set of tasks: "card-and-envelope" and "CD player."	To understand how to support a PWD through a multistep task, so they could achieve the task independently by investigating the relative effectiveness of different prompts for PWD during multistep tasks in the home. And, to inform prompting technology design	MMAT design: 3 Quantitative non-randomized	Nine dyads of participants (PWD + FC/relative). The participants were 5 men, 4 women, aged 73–86, with mild to moderate dementia.	Each visit took place at the home of the PWD, with the carer present, an OT and an engineer. Each prompting test was video recorded to allow detailed observation to be carried out after each visit was concluded	n/a. They did 67 visits in total to the nine dyads, with typically three trials on each visit.	n/a	n/a	Text and audio prompts were each more effective than video or picture prompts for a card-and-envelope task, but this was not seen in a CD player task. Designers of technology-based prompts for PWD should consider that the effectiveness of different prompts is likely to be task dependent. Familiar language may increase success of tailored prompts

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https://doi.org/10.2147/CIA.S357860 DovePress

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Enshaeifar et al. (2018)[30] Health management and pattern analysis of daily living activities of people with dementia using in-home sensors and machine learning techniques. PLOS ONE 13(5): e0195606 DOI: 10.1371/journal.pone.0195606, UK	THIM, Technology Integrated Health Management is a technology assisted system that uses Internet of Things (IoT) to enable continuous monitoring of PWD in their homes. Developing machine learning algorithms to analyze the correlation between environmental data sensors collected by IoT in order to monitor and facilitate physical well-being of PWD	To test whether a technology assisted monitoring system with in-home sensors (2 PIR sensors, 2 motion sensors, 2 pressure sensor, 1 door sensor, 1 central energy consumption monitor device) that used Internet of Things (IoT) which enabled continuous monitoring of PWD in their own homes. Also, Bluetooth-enabled medical devices recorded physiological data, ie blood pressure, heart rate and body temperature, weight and hydration readings twice a day. Analysis of raw observations and measurement data alongside environmental data, collected from their homes to investigate support of the physical well-being of PWD	MMAT design: 4 Quantitative descriptive	12 PWD and 12 carers	Machine learning algorithms were developed with different temporal granularity to process the data for long-term and short-term analysis on basis of environmental data collected by IoT technologies in the homes. Higher-level activity patterns were extracted, which were used to detect any change in patients' routines. The researchers also developed a hierarchical information fusion approach for detecting agitation, irritability and aggression in order to monitor and facilitate the physical well-being of PWD, and which enabled the carers to provide reassurance and allowed both participants to contribute	6 months	n/a	n/a	The algorithms are based on evaluations conducted by using sensory data collected from homes of PWD. This is a new approach to profile the daily patterns of PWD, to assist in diagnostic work and detect changes in their routines. The proposed techniques are able to recognize agitation and unusual patterns with an accuracy of up to 80%

Farina et al. (2019)[31] Acceptability and feasibility of wearing activity monitors in community-dwelling older adults with dementia. Int J Geriatr Psychiatry, 34, 617–624. DOI: 10.1002/gps.5064, UK	A wrist-worn acceleration sensor and activity monitor, lightweight and waterproof. The device can record up to 45 days without charging, and commonly used with older adults	To evaluate the acceptability and feasibility of PWD wearing activity monitors	MMAT design: 1. qualitative	26 community-dwelling, people with mild dementia with an unpaid cohabiting care.	All participants made notes in a diary about using the device. After the trial, the researcher completed quantitative questionnaires (QUEST 2.0, MoCA, EQ-5D and RAPA) and a qualitative interview to explore the dyads opinions and satisfaction of wearing the device and physical activity levels. The activity monitors were collected afterwards. An occupational therapist and a user interface engineer did all the visits	1 month	Participants tended to find wearing the activity monitors acceptable with only three participants (12%) withdrawing prior to the study end date	Participants wore the device up to 1 month with few issues.	Participants were generally satisfied with wearing the devices as measured by the QUEST (Mdn = 4.4, IQR = 1.1). Four themes were identified that influenced perceptions of wearing the device: external influences, design, routine, and perceived benefits
Fowler-Davis et al. (2019)[32] Potential for digital monitoring to enhance well-being at home for people with mild dementia and their family carers. Journal of Alzheimer's Disease, DOI: 10.3233/JAD-190844, UK	3rings digital plug	To investigate whether the family carer could check the daily routines with PWD and whether it reduced burden of care. Plus sought to identify the effect on well-being for both PWD and FC	MMAT design: 4. Quantitative descriptive	30 dyads used the device for 4 months	Pre- and post-survey, semi-structured interview on subjective experiences of using the 3rings technology. Remote digital collection (daily patterns of use)	4 months	The device was acceptable to PWD of mild degree, living alone at home	Family carers and people with dementia reported a decline in well-being, but 18 reported a reduction in burden of care	Pwd reported a decline in well-being and increased frailty

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Harris et al. (2020)[33] A preliminary evaluation of a client-centered prompting tool for supporting everyday activities in individuals with mild to moderate levels of cognitive impairment due to dementia. Dementia (0) 0 1–7. doi: 10.1177/1471301220911322, UK	Tablet with touch screen and prompter to complete tasks.	To evaluate a personalized touchscreen digital prompter designed for home use	MMAT design: 3. Quantitative non-randomized.	Pwd and their primary carers. 11 dyads completed the trial	A tablet-based prompter suitable for PWD was developed, along with a detailed guidance manual. Carers loaded instructions for completing the task onto the prompter, and the PWD then used the tablet independently to complete a task. Eleven couples used the prompter 'out-of-the-box' with no support other than a guidance manual	4 weeks	8 of the dyads had successfully used the prompter	n/a	The majority followed the steps on the prompter, and FC were able to breakdown and load tasks onto the prompter. Eight couples used the prompter successfully to complete goals that they had identified in advance like preparing simple snacks and using a TV remote control. Preliminary evidence show that FC can use a touchscreen tablet, software and manual package to identify specific tasks and break these down into steps and that PWD can then follow the prompts to complete the tasks

Kaimakamis et al. (2017)[34] Development/Testing of a Monitoring System Assisting MCI Patients: The European Project INLIFE. IOS Press doi: 10.3233/978-1-61499-798-6-583, Greece	Wristband transmitting biosignals and interaction interfaces connected to a tablet and to a tele-monitoring platform with 19 different services; daily routine digital assistant, daily activity monitoring, brain exercise/ memory improvement, fall detector, driving assessment, e-doorbell, public transport usage support, socialization and communication, caregiving monitoring, patient management, distance medical intervention	To evaluate effectiveness of the intervention and its impact on quality of life of the older adults and their caregivers, and contribute to prolong independent living at home	MMAT design: 3 quantitative, quasi-experimental design	230 patients mild to moderate cognitive impairment, 160 family carers and 30 HCW	Pilot study 6–7 months and control phase with patients with same characteristics for 6 months. Both phases are evaluated with standardized questionnaires MMSE, IADL, EQ-5D, QOL-AD, PANAS and ZARIT. Usage of devices is monitored. Design of services was influenced by end users perceptions in focus groups	6–7 months	The system was well accepted by the participants.	n/a	Pre-liminary results show that the wristband monitored users' health status; blood pressure, heart rate, daily steps, and hours of sleep. Monitoring means transmission of the biosignals to HCW, and a smart decision system sends alerts warning and motivation messages to user/ FC. HCWs were excited about remotely monitoring of their patients. (INLIFE is an EU project with 7 partner countries. This paper only describes the Greek pilot)

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McCarron et al. (2019)[35] A Web-Based Mobile App With a Smartwatch to Support Social Engagement in Persons With Memory Loss: Pilot Randomized Controlled Trial. JMIR Ageing 2019, vol 2, iss. 1 doi: 10.2196/13378, USA	A mobile-phone application called Social Support Aid - SSA employing a facial recognition software to assist memory and to promote social engagement to remember names and relationships of people they interact with	The objectives were to ascertain the feasibility and utility of the SSA, whether the outcomes of SSA use suggest potential benefits for people living with memory loss and their FC, and finally how study design component could inform a subsequent RCT to evaluate the potential of the SSA	MMAT design 2. Quantitative: RCT	Individuals with dementia, memory loss, or memory concerns. 29 of 48 participants were diagnosed with dementia. 25 women and 23 men. Mean age 74.90. FC 35 (25 women, 10 men). Mean age 67.83	RCT with 20 in intervention group and 28 in control group. Data collection at baseline, 3 months and 6 months + individual interviews with participants in the intervention group by 6 months	6 months	The SSA was found less useful due to complexity enrollment procedure, impracticality, stigma and functionality of SSA	SSA facial recognition did not improve QoL and social interactions	Assistive technology that allows persons living with memory loss to maintain some level of autonomy should be a priority

McCauley et al. (2019)[36] Evaluating user engagement with a reminiscence app using cross-comparative analysis of user event logs and qualitative data. Cyberpsychology, Behavior, and Social Networking, vol 22(8) DOI:10.1089/cyber.2019.0076, UK	Reminiscence app "InspireD" co-created for tablets	To evaluate usage of reminiscence app by PWD and FC, and compare data generated from app usage alongside the qualitative interview. To determine statistical power across all parameters to determine sample sizes that would be required to detect effect on different part of the analytical model	MMAT design 5. Mixed method. Trial and individual interviews with PWD and FC. Electronic event log data to register usage of app	28 dyads with PWD and FC were recruited (N=56). 25 dyads engaged regularly with the reminiscence app	The intervention consisted of reminiscence training, information technology training and a 12-week trial of independent use and electronic event logging by use of machine learning to typify the user engagement patterns. Thereafter, interview with 14 PWD and 16 FC	12 weeks + initial training	Dyad engagement in the app was clustered into four groups, of which three clusters reported a sense of gain and self-confidence by PWD and FC	FC with negative views on technology limited development of technological programs for PWD and reduced potential to enhance relationships through use of the app	The study provides insights of the app usage through event logging and qualitative interviews. FC engagement was vital to support PWD in using the app. The nature of the relations was a significant factor for dyads less engaged with the app usage. The methods used complemented each other, and this indicates the value of adding qualitative data to enrich the description of why certain patterns exist, as the log data only explains what patterns exist
Megges et al. (2018)[37] User experience and clinical effectiveness with two wearable global positioning devices in home dementia care. Alzheimer's & Dementia: Translational Research & Clinical Interventions 4 (2018) 636–644. doi: 10.1016/j.trci.2018.10.002, Germany	Two similar commercially available GPS watches, with location and telephone function. FC received a smartphone that could locate last recognized position of PWD	The aim was to perform an in-depth comparison of the user experience (UX) of the two GPS watches by the PWD and their FC. To get information about effectiveness and user satisfaction	MMAT design: 3. quantitative non-randomized, crossover design (sequences AB-BA)	20 dyads of PWD and FC	Products A and B were compared using two study periods, four assessment points. Each product was tested at home for 4 weeks. The first study period lasted from baseline at T1 to T2.1, and the second study period lasted from T2.2 to T3	4 weeks for each GPS watch + training courses = 8 weeks and 60 minutes training session prior to the trial.	The final 17 dyads rated usability, telephone function, design features, and battery capacity on device B significantly better that device A. PWD rated the design features and buttons of device A better than the FC	n/a	The results support specific design recommendations for GPS watches, with few buttons, clear text display and batteries lasting for at least 24 hours

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Author, Year, Title, Journal, DOI and Country	Type of Technology	Aims and Purposes of the Study	Design According to MMAT	Number of Participants with MCI/D, Family Carers and Staff + Age	Method	Duration of Intervention	Report on Usability and Acceptability	Impact on QoL, Occupational Performance and Human Dignity	Results
Nauha et al. (2018)[38] Assistive technology at home for people with a memory disorder. Dementia, vol 17(7) 909–923. doi: 10.1177/1471301216674816, Finland	Supportive devices and alarm systems in the home: GPS bracelet, web/simple video chat tablet computer, motion and pressure alarm, and a reminder connected to a motion sensor activating a verbal message: remember to turn off the tap	The aim was to assess in practice whether AT support and facilitate the work of HCW and of FC, and whether the AT support the independent living and security of a person with memory disorder both at home and in an assisted living. Two perspectives of AT benefits: functional utility and usability	MMAT design; 3. Quantitative non-randomized	5 PWD in an assisted living with 8 nurses, 4 PWD in home environment with 3 FC and 1 HC team	Questionnaires, diaries and logged data were used to evaluate the benefits of the devices	92 days	Technical problems, complex user interface and inadequate sound quality were primary factors reducing utility of the devices	n/a	Simple aids and alarms that did not need adjustments were considered most useful by FC and nurses although multiple false alarms occurred during the test period. Technical problems, complex user interface and inadequate sound quality were primary factors reducing utility of the devices

Øksnebjerg et al. (2020)[39] A tablet app supporting self-management for people with dementia: Explorative study of adoption and use patterns. Ageing & Mental Health. Doi: 10.1080/136607863.2019.1625302, Denmark	ReACT app, a holistic solution tailor-made to meet self-management needs of people with early-stage dementia	Aim of study was to explore the feasibility of and intervention merging methods of cognitive rehabilitation and self-management groups for people with early-stage dementia, as well as to explore the potential of such an intervention to promote adoption of the ReACT app	MMAT design: 5. mixed method	19 PWD and their FC. 4 men, 15 women, aged 52–79. FC: 11 men, 8 women, aged 51–83	This study aimed to (1) evaluate the applicability and usability of an app, tailor-made for people with dementia; (2) explore factors affecting adoption; (3) explore the possible influence of caregiver involvement; and (4) contribute to process evaluation of the intervention	13 weeks. First 2 weeks with individual sessions, thereafter 10 weeks with group session, and finally the last week with one individual session	n/a	The adopters rated the app higher in usefulness satisfaction and ease of use compared to non-adopters	The pilot study demonstrated that participation in a program with both individual and group session was both feasible and applicable method to address individual goals of rehabilitation. Such a program may be effective for adoption of AT among people with early-stage dementia. Also differences between adopters and non-adopters of PWD and FC was found. Adopters performed significantly more operations in the app during the intervention

(*Continued*)

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Table 3 (Continued).

Author, Year, Title, Journal, DOI and Country	Type of Technology	Aims and Purposes of the Study	Design According to MMAT	Number of Participants with MCI/D, Family Carers and Staff + Age	Method	Duration of Intervention	Report on Usability and Acceptability	Impact on QoL, Occupational Performance and Human Dignity	Results
Schmidt & Wahl (2019)[40] Predictors of performance in everyday technology tasks in older adults with and without mild cognitive impairment. The Gerontologist, vol 59, no. 1, 90–100 doi: 10.1093/geront/gny062, Germany	Assessment of performance of three devices; blood pressure monitor, mobile phone and eBook reader among older adults with and without MCI	The primary aim was to explore the role of MCI for performance in tasks with everyday technology. Therefore, older adults with and without MCI were compared regarding completion time, and error rate in using a blood pressure monitor, a mobile phone and an eBook reader. The second aim was to identify factors associated with task performance	MMAT design: 3. Quantitative non-randomized, quasi-experimental design	80 older adults, 39 MCI and 41 without MCI	Standardized observation based on video recording and coding was combined with cognitive testing and assessment of social-cognitive variables (self-efficacy, perceived obsolescence, attitudes towards technology)	29 months (spring 2012 - autumn 2014)	n/a	Regarding performance age had no significance, sex explained a small amount of variance in completion in the favor of women, and higher education was beneficial both in doing fewer errors and in interaction effects with cognitive components	Cognitively healthy participants outperformed those with MCI regarding completion time and errors. Social-cognitive factors contribute to differences in performance on everyday technology tasks in addition to cognitive abilities. Training programs may profit from considering respective individual resources or limitations in the cognitive, personality-related or emotional-motivational domain

Tyack et al. (2017)[41] Viewing art on a tablet computer: A well-being intervention for persons with dementia and their caregivers. Journal of Applied Gerontology, vol 36(7) 864–894 doi: 10.1177/ 0733464815617287, UK	Tablet computers for displaying art.	The aim was to explore if art-based intervention could be delivered by a tablet computer	MMAT design: 5. Mixed method. Quasi-experimental repeated measures design and qualitative interview	24 dyads (12 PWD) Age 64–90 Mean aged 75 for PWD, and 48–77 Mean age 66 for FC	Standard questionnaires QoL-AD, VAS with measures of well-being taken before and after each tablet use were compared. The qualitative data were collected after the trial, and interviews were analyzed using thematic analysis to answer the three research questions	2 weeks. The participants were expected to use the tablet at least 5 times during 2 weeks	Two PWD reported increased ability to use the app over time. Half of the FC were surprised that PWD succeeded to use the app, and what they noticed. Four dyads had demonstrated the app to others	A positive impact on the dyad relation, cognitive and emotional functioning and behavior	Quantitative data showed a significant effect for change in composite well-being and that using the app created a new sharing activity for the dyads. Qualitative data included changes in cognition, behavior and mood, and relationships, which was viewed positively. The results suggest touchscreen-based art interventions could yield well-being benefits for this population

Abbreviation: PWD, people with dementia; FC, family caregiver; HCW, health care worker(s).

https://doi.org/10.2147/CIA.S357860 DovePress

devices to support people with dementia at home: a GPS bracelet, a web chat tablet computer, an audio alarm and a motion sensor with reminder.[38,43]

Usability and Acceptability of the Technologies in the Reviewed Papers

The answers to the second research question about the outcomes of using the technologies with regard to usability and acceptability will be presented in the five sections below.

Wearables

The purpose of the studies in Group 1 was to monitor people with dementia and their body functions, report on activity, and report physical and physiological markers of significance.

One pilot study from Greece, as part of the EU project INLIFE, explored a wearable wristband connected to a tablet and a telemonitoring platform. The wristband transmitted bio-parameters such as blood pressure, heart rate, daily steps, and hours of sleep. The application provided alerts, warnings and motivational messages to the user and family caregiver. The 230 participants with MCI/D, 160 family carers and 30 health care staff accepted the technology, and health care staff were enthusiastic about being able to remotely monitor patients. Usability of the wristband was not reported.[34]

A second study tested usability and acceptability of two equivalent GPS clocks on 17 dyads among individuals with MCI/D and their family caregivers. They tested one of two commercially available smartwatches for four weeks. Thereafter, the dyads tried the second smartwatch for four new weeks. The results showed that even though the products were similar, the dyads preferred one smartwatch over the other, resulting in new knowledge on design features. The device should contain few buttons, show a clear font with parsimonious text, and have a battery capacity of at least 24 hours. The usability score decreased after four weeks of use, which may indicate that the users' expectations could not be fully met or that technical difficulties may have contributed to fewer ratings of usability.[37]

One study by Farina et al measured physical activity in 26 community-dwelling people with dementia using wrist-worn activity monitors and evaluated acceptability and feasibility of the monitors.[31] The study found that most of the participants were underactive. The wristband was accepted and was feasible for use by people with dementia. Furthermore, the participants saw project participation as vital to learning about their own activity profile as well as to contributing to dementia research. The participants' suggestion for avoiding non-use of the activity monitors was to incorporate the device as part of a daily routine. However, technology malfunctions were reported in eight of the 17 activity monitors, which failed to report all activity during the four weeks. The eight devices stopped recording prior to the 30-day record capacity, probably due to battery insufficiency. The reason why the devices could not record during the whole period of only 23 days may have been due to an error in the device or because the researcher provided a device that was not fully charged.[31]

A more common wearable is hearing aids. It was hypothesized that older adults with MCI/D and age-related hearing loss (ARHL) would demonstrate fewer behavioral symptoms if provided with binaural hearing aids. Binaural aids are devices that are fitted to both ears and connected to give an overall sound. This ensures that the wearer can understand their surroundings without being overloaded with too many different sounds. The study found that access to hearing aids neither reduced neuropsychiatric symptoms nor increased quality of life. The paper did not report on usability or acceptability.[28]

Environmental Sensors and the Internet of Things

Group 2 concerns technologies that have emerged from smart homes and home-based technology aimed at promoting safety and well-being using the Internet of Things (IoT). One study (Technology Integrated Health Management (THIM)) discussed a technology-assisted monitoring system that uses IoT.[30] It combined machine learning algorithms to analyze the correlation between environmental data (from PIR sensors, movement sensors, door sensors and pressure sensors) and psychological data (from measuring blood pressure, heart rate, body temperature and weight, and hydration twice daily) to detect changes in health status and well-being in people with MCI/D. The algorithms were trained to recognize agitation and unusual patterns with up to 80% accuracy, which is useful for diagnostic work and decision-making in

caring for and supporting people with MCI/D and their family caregivers. The paper did not report on usability or acceptability of the technologies.[30]

A second study explored how family caregivers could monitor a non-cohabiting person with dementia by monitoring sensors (3rings digital plug) connected to a bedside lamp, TV or electric kettle via a mobile application. After a four-month trial, all the individuals with dementia were happy to be connected to the family caregiver through the device, and 18 of the 30 family caregivers reported a decrease in burden of care. If no alerts occurred in the morning, they could relax. This study provided an understanding of the use of monitoring technology, and the device was found acceptable and useful by the participants.[32]

Mobile Applications

The objective of the assistive technology presented in Group 3 was to support memory in people with MCI/D to better cope with daily activities and to better structure their everyday life. Applications made for smartphones can contain different functionalities. One study described a holistic cloud-based solution with a calendar that interacted with other features such as contacts, diary notes, memos and checklists, and that explored the applicability and usability of such an app for people with MCI/D and for their caregivers.[42] The participants, 112 people with MCI/D and 98 family caregivers, had to download and activate the app themselves. Sixty-five people with MCI/D used the app for 90 days. They were divided into four groups according to frequency of use: 1) short use, 1–10 days, 2) early abandonment, 11–31 days, 3) late abandonment, 32–90 days, and 4) adopters, 90 days or longer. Different methods were used to investigate usability and applicability of the app and how often it was used. Timely introduction may explain successful adoption. However, 47 of the participants with MCI/D and 78 of the family caregivers never activated the app. The reasons for this varied; some felt it was too early to introduce the application or found it too difficult to use, while others preferred to buy alternative off-the-shelf solutions or to continue with a paper diary. The small number of participants made it difficult to draw any conclusions.[42]

Another study examined the use of a reminiscence app with 30 dyads of MCI/D and family caregivers for 12 weeks.[36] A technology-based reminiscence app can facilitate opportunities for people with MCI/D to retain an empowered role and enjoy conversations around memories. However, access to relevant materials relies on the caregivers' willingness to participate and on source memorabilia. The study aimed to investigate how the dyads engaged in the app and how machine learning could identify behavioral clusters that typified different levels of user engagement. The participants were divided into four clusters: 1) independent and consistent use of the app, 2) reliant on family caregiver for support in using the app and unpredictable usage patterns, 3) highly reliant on family caregiver for engagement with the app and inconsistent usage patterns, and 4) infrequent usage. The family caregivers' views on and attitudes toward the technology impacted the relationship with and significance of the app. Those who did not accept the app could not support its use.[36]

A third study explored the feasibility and utility of a web-based mobile app and smartwatch called Social Support Aid (SSA) employing facial recognition software. It aimed to promote social engagement by assisting older adults with memory impairment to recall people they interacted with. The app was tested by 20 participants in the intervention group and 28 participants in the control group, with data collection after three and six months.[35] The facial recognition failed because the camera only worked from certain angles. It took time to take photos and did not work in all types of lighting. Moreover, some found the device too heavy and bulky to carry around the neck, and the text too small to read. After six months, most of the participants concluded that the app was not useful for reasons of complexity and functionality, impracticality and stigma, and the enrollment process. However, some participants felt the device had potential to be useful and recommended improvements.[35]

Tablet Computers

One study explored how a tablet computer could prompt multi-step tasks at home for people with MCI/D by providing instructions in the form of text, photos/pictures, video clips or verbal messages. The study found that instructions with photo/picture prompts and video prompts required too much interpretation and therefore distracted the users if used alone. The combination of recorded voice audio prompts reinforced with text prompts was more effective, powerful, and best understood.[29]

Another study explored whether a "DIY-kit prompter package" consisting of a touchscreen with a user-friendly interface, a multi-step prompting software, and a manual could be used independently by people with MCI/D and their family caregivers at home, with little or no training.[33] The prompter package aimed to support people with MCI/D to cope independently with daily tasks such as food preparation and household chores. Fourteen dyads were recruited, of which three withdrew and 11 participated by trying the prompter package for four weeks. All 11 family caregivers reported to have succeeded in loading at least one activity and its steps onto the tablet. Eight of the 11 people with MCI/D had been able to read and follow the steps and complete at least one activity successfully. There were no significant differences between the participants regarding cognitive functioning, though the successful dyads used the prompter more often than the unsuccessful dyads. Another finding was that family caregivers initiated use of the prompter more often than did the person with MCI/D.[33]

One study described how an art app on a tablet computer could be used for art-based interventions to provide well-being in 12 people with MCI/D and their family caregivers.[41] The aim was to explore the impact of viewing art on a tablet computer; how it impacted subjective well-being in people with MCI/D, how they experienced the activity, and the family caregivers' impressions of the impact of the activity on their relative. The tablet contained pictures from different art genres, and the dyads were asked to use it at least five times over two weeks. The art viewing sessions lasted 20 minutes and included 30 pictures on average. The qualitative findings indicated that reminiscence and cognitive stimulation occurred spontaneously, that the dyads had enjoyable conversations, and that they found a new shared activity that led to engagement in new activities such as visiting an art gallery or collecting new images from library books. The results suggest touchscreen-based art activities to be usable, acceptable and to yield well-being for this target group, ie older adults with MCI/D.[41]

Supportive Devices and Safety Systems

Some assistive technology may be presented as having a supportive purpose for home-dwelling people with MCI/D and their family caregivers. One German study assessed the occupational performance of 80 older adults, 39 with MCI and 41 healthy controls, using a blood pressure monitor, a mobile phone and a paper diary.[43] By video-recording their performance and analyzing the video clips, they compared the two groups' performance and handling of assistive technology. People with MCI made more mistakes and needed more support in using the devices than the healthy controls. Frequent errors included incorrect arm position or placement of the blood pressure cuff. The attitudes toward technology did not differ between the groups, even though all of them were relatively inexperienced users of technology. The study did not report on usability or acceptability of the technologies.[43]

Another study in this group explored the ability of four different assistive technologies to support family caregivers' work and to support independence in people with MCI/D: a GPS safety bracelet, a web chat tablet, a short-range audio alarm and a reminder with motion sensor.[38] The four technologies were tested for 25 and 38 days by four people with MCI/D at home and five people in an assisted living facility, respectively. The solution with the motion sensor and the mat pressure sensors connected at the short-range alarm to monitor door exits was perceived as useful and easy to use, despite seven of nine participants finding the sound quality poor. However, the study revealed problems regarding disturbances affecting the video phones and the battery in mobile applications quickly running out of power. The technology based on wireless networks and browser-based service management systems was particularly susceptible to failure. Far from all these issues could be resolved during the project period. The conclusion was that assistive technologies have the potential to support people with MCI/D and their family caregivers if the devices are found usable and easy to install, maintain and tailor individually to the user.[38] In sum, findings on user-friendliness and acceptability of technology among the user groups continue to diverge.

Impact on Occupational Performance, QoL, and Human Dignity for Independent Living

Our third research question dealt with the impact of the technologies on occupational performance, QoL, and human dignity for independent living. Column nine in Table 3 presents the findings related to QoL, occupational performance, and human dignity in the reviewed studies (Table 3). None of the papers reported any explicit impact of technology to improve QoL in the participants. Some terms other than "quality of life" were used, ie reduced burden of care and positive impact on relationship, which can be linked to QoL.[32,36,41] The term "occupational performance" was reported in

only one of the 14 papers, ie on occupational performance from using three different devices.[43] Human dignity was neither studied nor reported in any of the 14 papers.

Purposes of Digital Assistive Technology in the Review

Table 4 presents an overview of technologies evaluated and grouped according to the Norwegian Directorate of Health's categorization, also used in our 2017 review:[15] However, multi-purpose technologies were challenging to categorize since they could fit into more than one category.

- technology for safe walking indoors and outdoors,
- technology for safety at home,
- technology for independent living, and
- technology for entertainment and social communication.

Discussion

This review aimed to compare the technologies explored in trials with older adults with MCI/D from the decade 2007–2017 and from the past three years (2017–2020), and to discuss usability and acceptability of new digital solutions regarding occupational performance, QoL, and human dignity for independent living. To summarize, we found that assistive technology solutions seem to have become more multifunctional over the past three years, with wearables, apps and sensor technology often combined with computers, functionality for two-way communication, with or without a camera. The studies placed more emphasis on supporting coping strategies and independence in the person with MCI/D by use of apps, and computer technology for entertainment, cognitive stimulation and for prompting successful performance of tasks to improve independence and well-being.[29,33,36,38,41,42,44] Furthermore, sensor technology for monitoring physical health markers such as blood pressure, oxygen uptake, heart rate, etc. and for monitoring environmental conditions such as indoor temperature, controlling lighting, detecting presence or falls, predicting actions and alerting if something is wrong.[30,32,34,43] This may indicate that the smaller studies elaborated knowledge that could be built on in quantitatively designed studies. It may also be that digital assistive technologies have become cheaper and more available for research projects. Monitoring technologies make it easier to evaluate use and benefit through logged events.

Interestingly, the search results in September 2020 for the previous three years (2017–2020) identified far more studies on trials than did the 2017 search for the period 2007–2017, with 1452 titles compared with 359 in 2017. Many studies on digital assistive technology among various user groups are currently taking place worldwide, and although MCI/D and home-dwelling people were inclusion criteria, several papers that also appeared in the search results reported on acquired brain impairment (ABI), cognitive impairments in children and adolescents, studies in nursing homes, and lab studies.

Moreover, the number of participants had also increased in terms of people with MCI/D, family carers, and health care workers (Table 2). A quick calculation reveals a tendency toward including almost twice as many participants in the studies in the 2017–2020 review, as in the 2007–2017 review.

The technologies explored in trials with people with MCI/D and their family carers seem to have shifted since the 2017 review from stand-alone devices at home toward technologies that can be worn on the body to monitor body functions and report states or imbalances. Moreover, research interest is more focused on mobile phones with apps and in wearables providing reminders and timely support, and monitoring health status.

Types of Technology

As stated above, digital assistive technologies seem to have developed between the two reviews, and have become smaller, more integrated systems, often with multiple purposes.[30,34] Three strategies for support seem evident: prompting and reminding people with dementia, and monitoring people with dementia at home using environmental sensors and biosensors, and providing safety outdoors using GPS.[30,32,37,38,43] Several of the papers aimed to evaluate feasibility and usability of the devices, reveal the preferred kind of prompting format, and to offer compensatory strategies using different apps.[29,33,35,36,42] A few studies aimed to explore how tablet computers can offer entertainment and meaningful leisure.[41,44] In the screening process we came across several papers describing trials with robot technology and augmented reality (AR).[45–50] However, these were lab studies, or scoping studies and thus did not meet the inclusion criteria in the current review. Moreover, earlier

Table 4 Overview of Types and Purposes of Technologies

Domain 1: Safe walking indoors or outdoors	
Type of technology	**Purpose**
Two commercially available GPS watches (Megges 2018).	Two-way communication enables guiding the person, promoting safe walking, and localizing the person.
GPS safety bracelet, web chat computer, alarm, and reminder with motion sensor (Nauha 2018).	To support independence and security in people with dementia Enables monitoring and localization.
Domain 2: Safe living	
Type of technology	**Purpose**
Sensors communicating to support ADL by IoT. (Enshaeifar 2018).	To monitor physical well-being in PWD at home, a technology assisted monitoring system with environmental sensors (2 PIR sensors, 2 motion sensors, 2 pressure sensors, 1 door sensor and 1 central energy consumption sensor) using Internet of Things (IoT) where installed. Furthermore, biomedical sensors to monitor blood pressure, heart rate, body temperature, weight and hydration were activated twice a day.
3rings digital plug for FC remote digital monitoring of daily patterns of use. (Fowler-Davis 2019).	To investigate whether FC' checking of daily routines for people with dementia could reduce burden of care and provide well-being for both the person with dementia and the FC. The 3rings digital plug was used on the kettle, TV and bed lamp.
Monitoring system to assist people with MCI at home (Kaimakamis 2017).	Wearable wristband connected to tablet and telemonitoring platform with bio-parameters for blood pressure, daily steps, and hours of sleep.
Domain 3: Facilitate independent living	
Type of technology	**Purpose**
ReACT app for mobile phones comprising a calendar interacting with diary notes, contacts, checklists, and memos (Øksnebjerg 2020).	To support memory and structure daily living routines.
A reminiscence app (McCauley 2019).	To facilitate opportunities for people with MCI/D to retain an empowered role and enjoy conversations around memories.
A web-based mobile app and smartwatch (McCarron 2019).	To promote social engagement by assisting older adults with memory impairment to recall people they interact with.
Evaluating use of a blood pressure monitor, a cell phone and e-book reader (Schmidt & Wahl 2019).	To evaluate performance and handling of the three devices in order to compare two groups of older adults, one with and one without MCI.
A tablet computer with a software program that is set up by FC (Harris 2020).	To provide instructions for how to independently cope with multi-step tasks like food preparation and household chores, by one of three chosen prompting mediums: text, pictures or audio recordings.
Tablet computers prompting multi-step tasks (Boyd 2017).	To prompt multi-step tasks at home for people with MCI/D, by providing instructions in text, photos/pictures, video clips or verbal messages and to identify what prompting format was most suitable for PWD.
Wrist-worn activity monitors (Farina et al 2018).	To measure physical activity and evaluate acceptability and feasibility of wearing activity monitors.
Binaural hearing aids for age-related hearing loss (Adrait 2017).	To give an overall sound, which ensures that the wearer can understand the surroundings without being overloaded with too many different sounds. This may demonstrate fewer behavioral symptoms.
Domain 4: For entertainment and social communication	
Type of technology	**Purpose**
Tablet computers to view and discuss art (Tyack 2017).	To improve well-being in PWD and their FC by viewing art together.

trials have stressed usability issues such as user interface applicability for people with dementia. Grundy stated that technology should aim to make challenges associated with ageing less limiting.[51] We would like to add challenges associated with cognitive impairment. Thus, new technology, which to a great extent is wearable or is provided as apps, must be explored with regard to user interface applicability for people with MCI/D. Moreover, wearable technologies should be comfortable, self-explanatory, usable, and acceptable by older adults with MCI/D.

Regarding Usability and Acceptability of the Technologies in the Review

Usability and acceptability are important to ensure older adults' adoption of technologies. Column 8 in Table 3 presents details on usability and acceptability of the technologies explored in the trials. None of the papers explicitly addressed the concepts of usability and acceptability. Five of 14 papers did not use these terms at all. However, some used the terms useful, successful use, sense of gain, acceptable or utility in the sense that the technology may be user-friendly and of use. Two of the papers reported less usability of the technology due to technical problems, functionality, and complex user interfaces.[35,38]

User-friendly technology is perceived as a requirement for acceptability and adoption. The need for adapting technologies to older adults' individual skills and preferences determines whether the technology will be used and found acceptable Person-centered tailoring of digital assistive technology is thus important. Research has found that appropriate services based on a whole systems approach to care is of importance to facilitate technology-enriched accommodation for people with dementia.[52] Such knowledge indicates that a more extensive collaboration between health care and technology development companies is required to ensure that technology enriches older adult's accommodations in a trustworthy way rather than create barriers and unreliable services. Moreover, user participation workshops for piloting technology regarding interfaces, user-friendliness, etc. will still be required to optimize usability and acceptability.

A more recent term, "intuitive design", defines intuitive use as a characteristic of the interactive process between a specific user and the design.[53] It means that the product's design is based on principles from other domains that are well known to us, so that we can use our past experience to reason how it should be used. The designer must thus acquire knowledge of the target audience in order to succeed. None of the reviewed papers discussed intuitive design. This actualizes the call for user involvement in research and technology development.

Impact on Occupational Performance, QoL, and Human Dignity for Independent Living

The main interest in the 14 reviewed papers concerned feasibility and effectiveness of the technology. One study only explored occupational performance (Schmidt and Wahl). No questions were asked about QoL or human dignity. We may interpret this to indicate that developers are more interested in the technological features and possibilities than in how the technology influences everyday living. We argue that timely access to technology may support people with MCI/D to better cope with everyday situations by facilitating and simplifying occupational performance. This may lead to an improved sense of quality of life and human dignity.[54] Most of us have an innate need to master daily activities that are important to us and to be respected as human beings. If technology were to address these issue, maybe more older adults would be willing to adopt digital assistive technology.

User Involvement in Technology Development Research

None of the papers reported on user/caregiver/stakeholder involvement in the design process of the technology evaluated. However, one study invited participants to keep notes in a diary about using the device, and at the end of the trial they were interviewed about their opinions on and satisfaction with wearing and using the device.[31]

The current review demonstrates the necessity to evaluate new digital technology with the target groups. Recruiting people with MCI/D and their family carers to research projects will create knowledge about cognitive impairment and how consequences manifest in everyday living as well as how technology could be incorporated. Such knowledge contributes to improved awareness of user needs for people with MCI/D and their carers.

Careful assessment of and dialog with the target groups are needed to obtain this knowledge. It requires meeting places for mapping and discussing user needs and the time to exchange views. One study by Lund et al reports on dialog

cafés as a method of co-creation of knowledge.[55] The time aspect proved to be particularly important, since the participants needed time to acquaint themselves with the form of involvement, and to feel comfortable in the groups and with the technology topics that were introduced. The study gave an example of how dialog cafés facilitated user involvement and enabled older adults to express their needs and provide their perspectives on assistive technologies, which in fact directed research and development in the main project.[55]

Adoption of technology is known to be slow in older adults. One study on older adults' perspectives on assistive technology found that 60 of 82 respondents perceived themselves to be too old to get involved with technology. Furthermore, 55 of 82 agreed that technology was useful for others but not for them, yet 49 of 82 reported being accustomed to using computers, mobile phones and other technical equipment.[56] This may indicate that there are huge differences in older adults' knowledge of and practice in using technology. One may conclude that adoption of technology is dependent upon technology literacy. However, it could also be due to lack of information and training, of Wi-Fi or of the economic resources to buy equipment and subscriptions to data services and programs. One recent study found that older adults could learn to use a tablet with a touchscreen successfully through five coping strategies: 1. having a supportive environment encouraging the person to use it and offer help to do so; 2. interest and motivation were created when they realized they could continue doing meaningful activities on the tablet, such as reading newspapers; 3. operating the tablet seemed easy for many, which led to positive experiences and confidence in using it; 4. being able to maintain contact with family, friends and society was the most important aspect of using the tablet; and 5. having personal strategies to ease use of the tablet, such as using the little finger or a tablet pen to be sure to click on the right button contributed to a positive experience.[57]

Possible Biases

Several biases may threaten the credibility of our study. First, due to terminological variations in the databases and the large number of keywords in our search strategy, we had to convert the keywords to relevant MeSH terms for each database. For example, the original keyword "assistive technology" was converted to "assistive or self-help or everyday or daily living or dementia friendly or welfare, technology or device* or aid" (Table 1). However, using the same search strategy as in the 2017 review was found to be fruitful and appropriate for exploring the field three years later.

Moreover, the quality assessment process using the MMAT criteria was carried out separately by each author, before the three authors met to agree on the ratings. If any discrepancies arose, the author who had not rated the paper in question was asked to assess it.

Conclusion

Research interest in technology to support older citizens with MCI/D at home is increasing. This is important because there is a need for more knowledge on how technology works in practical settings and how it influences everyday living for people with MCI/D. This systematic review demonstrates that research studies conducted over the past three years have increasingly reported on wearable and environmental digital assistive technologies, often with multiple purposes. Three strategies for support seem evident: prompting and reminding people with dementia, monitoring people with dementia at home using environmental sensors and biosensors and providing safety outdoors. Nonetheless, dementia-friendly technologies have yet to be developed. Thus, there is still a need for further research on the impact of these technologies on occupational performance, QoL, and human dignity for independent living.

Acknowledgments

We want to thank librarians Linn Kristine Kristensen, Malene Wøhlk Gundersen and Hege Kristin Ringnes at Oslo Metropolitan University for their supervision and support in performing systematic searches in all the relevant databases.

Disclosure

The authors report no conflicts of interest in this work.

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